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BIOTELEMETERED DAILY HEART RATE CYCLES IN THE RED-TAILED HAWK *(Buteo jamaicensis)*

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Abstract - Daily fluctuations in resting heart rate (HR) were studied in a captive ♀ Red-tailed Hawk (*Buteo jamaicensis*) using radiotelemetry. HR's were recorded hourly during 10 consecutive days while the hawk was housed in an outdoor pen. Daytime HR's averaged 202 beats/min and were significantly higher than the average nocturnal HR of 134 beats/min ($P<0.001$). Maximum HR's (>200 beats/min) occurred crepuscularly, just after sunrise and before sunset.

Daily cycles of several physiological factors have long been known for a number of birds and mammals. In birds for example, marked nocturnal depression of body temperature has been demonstrated in Snowy Owls (*Nyctea scandiaca*) and Short-eared Owls (*Asio flammeus*) by Irving (1955). Odum (1941) commented on the marked changes in heart rate (HR) occuring between day and night in avian species. Smith et al. (1976) reported that telemetered HR is lower and less variable during darkness in the domestic Mallard Duck (*Anas platyrhynchos*). One method, that of telemetered HR, allows physiological study of unrestrained birds under near-natural conditions. This method has also been promoted as a suitable indicator of relative metabolic rate in homeotherms (Johnson and Gessaman 1973; Gessaman 1980).

Indications that HR can be a good relative metabolic indicator come from studies in which HR and O_2 consumption were measured simultaneously (Morhardt and Morhardt 1971; Lund and Folk 1976). Similarities between HR-ambient temperature curves and metabolism-ambient temperature curves have been demonstrated for birds such as the Burrowing Owl (*Athene cunicularia*) (Coulombe 1970) and Blue-winged Teal (*Anas discors*) (Owen 1969). Because of circulatory adjustments occurring during more intense locomotor activity, HR is only considered a valid metabolic indicator when an animal is unstressed and at rest, or exercising moderately (Jones and Wang 1976). We have used telemetered HR's to demonstrate stress in the Ferruginous Hawk (*Buteo regalis*) (Busch et al. 1978), but in order to use HR as a metabolic indicator, activity levels must be low and stress minimal.

Little of the aforementioned types of research have focused on birds of prey in spite of the emphasis on raptor conservation, rehabilitation and captive breeding. Our goal was to assess diurnal fluctuations in resting HR's of the Red-tailed Hawk via telemetry. Changes in HR were also compared with time of day and with extrinsic factors such as ambient temperature and elevation of the sun.

Methods

The subject of this study, a ♀ Red-tailed Hawk, was considered non-releasble by rehabilitation personnel because of an unmendable broken wing. This disability did not conflict with the study's goals since the bird's feeding and perching were not affected, and since our focus was on daily variations in resting HR.

The hawk was maintained in an outdoor pen measuring 56 m²

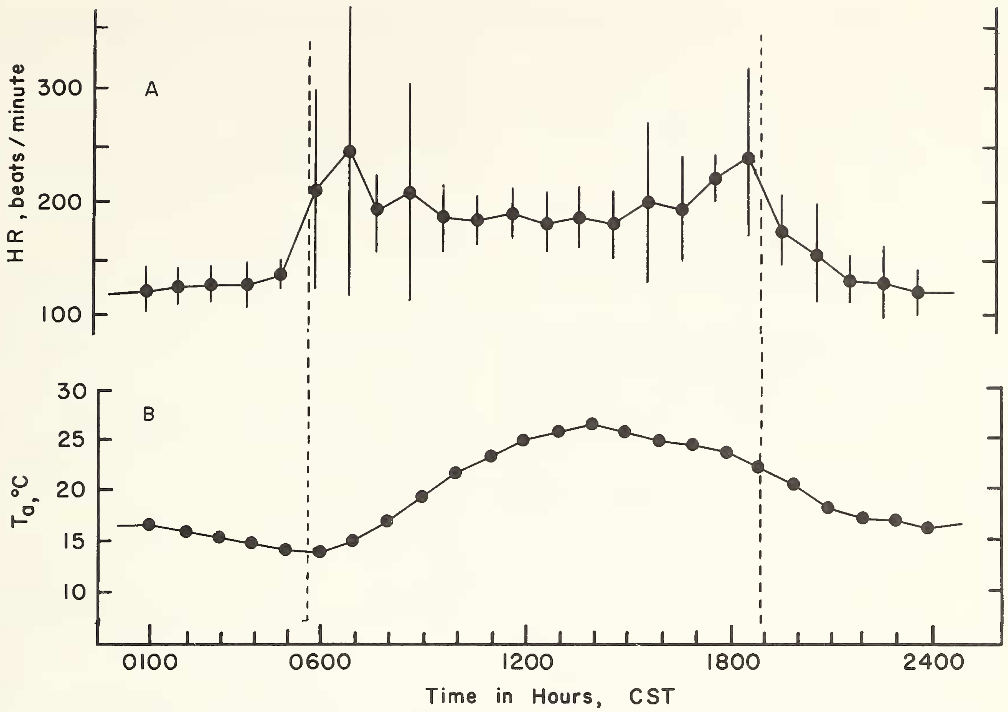

Figure 1. (A) Mean heart rates (HR) and (B) mean ambient temperatures during 10 consecutive days of recording. Vertical bars depict standard deviations for each hourly sample period (n=10 d).

located on the Allwine Prairie Preserve of the University of Nebraska at Omaha. Sources of disturbance were few at this rural site. A small building adjacent to the pen provided portholes for observing the bird, as well as electrical power and housing for the recording instruments. The desirability of such conditions was highlighted by Owen (1969) who measured significantly higher HR's in Blue-winged Teal under semi-natural conditions than under controlled laboratory conditions. Food for the hawk consisted of freshly killed laboratory rats placed in the cage at randomly selected times which did not coincide with hourly data collection.

Electrocardiogram electrodes were surgically implanted on the pleural surface of the bird's sternum through a mid-line abdominal incision, using a modification of the method of Sawby and Gessaman (1974). Leads from these electrodes provided the input to a Narco FM 110-E4 HR telemetry transmitter. The transmitter, packaged in dental acrylic and worn by the bird as a "backpack", weighed 109g with its harness. The transmitter assembly weighed 7.5% of bird's body wt (1.45 kg). This was within the 10% limit considered valid for electrocardiogram telemetry devices (Gessaman 1973).

The telemetered signal was detected with a Narco FM 1100-7 receiver. A switching device was designed to record a 2-min segment from each h of the day. This device also operated a tape recorder on which data were recorded in digital format as audible "clicks." Each click represented 1 QRS complex from the electrocardiogram (1 heart beat). High heart rates made counting audible clicks impractical so these data were coverted to an analog format using a Physiograph Cardiotach. The resulting chart records were analyzed to determine $\bar{X}$ HR for each 2-min sampling period, and to evaluate changes between hourly $\bar{X}$ HR's for more than 240 sample times. Data were collected continuously for 10 d between 9 and 18 April 1977. During this period daily $\bar{X}$ max. temp. was 24.1 ± 3.7°C (*n*=10), while the $\bar{X}$ min. temp. was 12.4 ± 3.1°C (*n*=10).

RESULTS AND DISCUSSION

The pattern of changes in $\bar{X}$ HR is displayed in Fig. 1A. The bimodality of the cycle, exemplified by 2 daytime peaks, prevented the use of sophisticated biorhythm analysis. However, simpler methods such as t-Tests are considered sufficient to demonstrate existence of daily biological cycles (Koukkari et al 1974). In this instance, one way ANOVA confirmed the existence of highly significant variation in HR (F=6.589; df = 23, 216; $P<0.001$). Furthermore, the diurnal $\bar{X}$ HR (202 beats/min) for the 14 h between sunrise and sunset was significantly greater than the nocturnal $\bar{X}$ (134 beats/min) (t-Test, $P<0.001$). Resting HR's were highest in periods just after sunrise and just before sunset.

Variability (i.e., standard deviation) in instantaneous HR was greatest near sunrise and sunset (Fig. 1A). For example, the average coefficient of variation was 80% between 0600-0900 but was only 28% during mid-day (1000-1400). Bartlett's test revealed highly significant heterogeneity in variances ($P<0.001$). Hourly changes in $\bar{x}$ HR were also greatest in the early morning and late afternoon. When hourly changes in HR's during the 5 h around sunrise (0500-1000) were grouped with those during the 5 h near sunset (1500-2000), mean changes in HR for these 10 h were significantly greater ($P<0.01$) than changes during the other 14 h of the day.

Although daily metabolic or HR cycles are not unusual for raptors (Coulombe 1970), bimodal patterns such as reported herein have been described infrequently (Nastosescu et al. 1975). The adaptive value of this crepuscular HR pattern is somewhat puzzling.

Parallel changes in $\bar{x}$ HR's and $\bar{x}$ ambient temp should not be regarded as a casual relationship, despite the well-established inverse relationship between avian metabolism and air temp outside of the thermoneutral zone. There is strong evidence that metabolic rhythms are more closely linked to photoperiod (Folk 1974) and that daily changes in HR coincide somewhat with those of ambient temp only because of their common relationship to solar periodicity. The distinctly bimodal peaks we observed contrast with the curve for ambient temp (Fig. 1B).

The possibility that higher heart rates near sunrise might represent elevation of metabolic rate required to raise the bird's body temp from a slightly torpid nocturnal condition was examined using the Van't Hoff relationship. Assuming a Q_{10} equal to 2.3, we calculated that a difference of 4.95°C would be required to account for the difference between nocturnal and daytime $\bar{x}$ HR. A change in body temp of this magnitude is unlikely in view of reports of body temp cycles in large raptors (Coulombe 1970; Gessaman 1978) and would not explain the evening peak at all.

We might expect to find an explanation for the bimodal pattern in HR in *Buteo* behavior, however Red-tailed Hawks do not seem especially crepuscular in their activities in the wild. Their soaring activity is greatest near midday when thermal convective currents are most favorable (Henty 1977). For most buteos many potential prey species are crepuscular. Since the foraging success of Red-tailed Hawks has been linked to behavior of primary prey species (Stinson 1980), the possibility cannot be discounted that the HR cycle demonstrated here parallels activity patterns of prey.

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Status of a Population of Bald Eagles Wintering in Western Connecticut

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In a previous study (H.I. Russock, *Raptor Research* 13(4): 112-115, 1979) a population of 4 Bald Egles (*Haliaeetus leucocephalus*) was observed on wintering grounds in western Connecticut during the winter of 1976-1977. The eagles congregated below a hydroelectric dam on the Housatonic River. The dam's generators kept the otherwise frozen river open and killed or injured large numbers of fish which the eagles preyed upon. This paper presents the results of subsequent observations made during the winter of 1982-1983 on the same population of eagles which grew to 17 individuals.

Eagles were observed in the vicinity of the Shepaug Hydroelectric Dam, Housatonic River, approximately 4.6 km north of Newtown, Connecticut. Above the dam, and created by it, is Lake Lillinoah with a surface area of 769 ha. Directly west, across Lake Lillinoah, is the Upper Pauggessett State Forest extending for 3 km north along the western shore of the lake. On the south side of the river, below the dam, is a large privately owned wooded hillside where eagles congregated. North, across from the hillside, is a hydroelectric plant owned by Connecticut Light and Power Company.

Most observations were made from the top of the dam and from a canvas blind constructed on the south side of the river, approximately 25 m from a frequent perching area. Other observations were made from a road running parallel to the north side of the river and from several locations northwest of the dam (when attempting to determine roosting sites). Observations were made with field binoculars (7x35) and a 600 mm photographic lens and were results dictated into a taperecorder or handwritten. A total of 178 h of observation were made between 8 December 1982 and 8 April 1983. Trips were made to the dam on 52 separate days, 34 of which resulted in sighting of eagles.

The first eagle observed was on 3 January 1983; 9 observation days in December did not result in any sightings. Eagles were last observed on 24 March 1983; during 6 observation days in late March and early April none were seen.

Due to unusually mild weather, the Housatonic River remained virtually free of ice during the entire winter. Therefore, the departure of eagles could not be correlated with the opening of the river in spring as it was during the winter of 1976-1977. It was not determined if the greater availability of open water elsewhere affected the number of eagles wintering in the vicinity of the Shepaug Dam. However, due to the abundance of fish at the dam, it is likely that all eagles wintering in the area frequented the dam.

Seventeen individuals were positively identified using plumage characteristics and other outstanding features;